LEEDS PHILOSOPHICAL AND LITERARY SOCIETY

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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A. A. COMMON, LL.D., F.R.S., President, in the Chair.

Lewis Evans, J.P., F.S.A., Barnes Lodge, King's Langley, Herts ; and

John Anderton Greenwood, B.A., LL.M., Brooklyn, Earl's Court Square, S.W.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

William Johnston, Saint Nicholas House, Westgate Street, Gloucester (proposed by J. McCarthy) ;

George Edward Lumsden, Assistant Secretary of the Province of Ontario, 57 Elm Avenue, Toronto, Canada (proposed by S. W. Burnham) ;

Major Percy Alexander MacMahon, R.E., F.R.S., Artillery College, Woolwich, and 52 Shaftesbury Avenue, W. (proposed by A. A. Common) ;

Louis C. H. Maston, Banker, San Francisco, California, U.S.A (proposed by H. H. Turner) ;

Beauchamp Prideaux Selby, J.P., Pawston, Cornhill-on-Tweed, R.S.O., Northumberland (proposed by John Browning) ;

J. E. de Villiers, Government Surveyor, Cape Town (proposed by David Gill); and
John Watson, Norman Villa, Glossop Road, Sheffield (proposed by W. J. B. Roome).

Two hundred and twenty presents were announced as having been received since the last meeting, including, amongst others:—

Cayley's Collected Mathematical Papers, vol. x., presented by the Cambridge University Press; Catalog der Astronomischen Gesellschaft, Zone +15° bis +20°, presented by the Society; the Indian Calendar, with tables of eclipses, &c., presented by Robert Sewell; Laplace, Œuvres Complètes, tome xi., presented by the Paris Academy; Lœwy and Puiseux, Atlas Photographique de la Lune, fasc. I., presented by the authors; W. T. Lynn, Remarkable Eclipses, presented by the author; Map of India, showing path of eclipse of January 1898, presented by the Surveyor-General; *Venus*-Durchgänge, 1874 und 1882, Bericht über die deutschen Beobachtungen, Band vi., presented by the German Transit of *Venus* Commission; Original negatives of *Jupiter* and the Moon, photographs of *Mars*, and Sun-spot, and portrait of W. Chauvenet, presented by the Lick Observatory; Series of thirteen transparencies of the Milky Way, &c., presented by E. E. Barnard; series of fifteen photographs of the Milky Way, &c., presented by Max Wolf; Photographs of the spectrum of the zinc arc, presented by Henry Crew.

Mean Areas and Heliographic Latitudes of Sun-spots in the Year 1894, deduced from Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. lvi. p. 11, and are deduced from the measurements of solar photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

Table I. gives the mean daily areas of umbræ, whole spots, and faculæ for each synodic rotation of the Sun in 1894; and Table II. gives the same particulars for the entire year 1894, and the five preceding years for the sake of comparison. The areas are given in two forms. First, projected areas—that is to say, as seen and measured on the photographs—these being expressed in

millionths of the Sun's apparent disc; and next, areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere.

Table III. exhibits for each rotation in 1894 the mean daily area of whole spots, and the mean heliographic latitude of the spotted area, for spots north, and for spots south, of the equator, together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots; and Table IV. gives the same information for the year as a whole, similar results from 1889 to 1893 being added as in the case of Table II. Tables II. and IV. are thus in continuation of the similar tables for the years 1874 to 1888, on pp. 381 and 382 of vol. xlix. of the *Monthly Notices*.

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (Observations of Solar Spots made at Redhill, by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon on 1854 January 1, and the assumed period of the Sun's sidereal rotation is 25·38 days. The dates of the commencement of the rotations are given in Greenwich civil time, reckoning from mean midnight.

TABLE I.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Mean of Daily Areas. Umbræ.	Projected Whole Spots.	Faculæ.	Corrected for Foreshortening. Umbræ.	Whole Spots.	Faculæ.
	days							
538	1893 Dec. 16·75	25	529	2785	1932	390	2119	2186
539	1894 Jan. 13·09	27	383	2174	1133	268	1553	1274
540	Feb. 9·43	28	319	1794	1692	234	1329	1874
541	Mar. 8·76	27	256	1390	1212	167	933	1297
542	Apr. 5·06	27	356	1949	1705	272	1518	1919
543	May 2·31	28	456	2417	1942	355	1870	2115
544	May 29·53	27	515	2681	1745	380	2034	1988
545	June 25·73	27	420	2315	2353	299	1695	2626
546	July 22·94	27	372	2093	1453	259	1477	1628
547	Aug. 19·16	28	201	1022	1560	142	736	1774
548	Sept. 15·42	27	331	1785	1867	230	1266	2110
549	Oct. 12·70	27	155	776	1990	120	617	2371
550	Nov. 9·00	28	186	1018	1534	136	773	1698
551	Dec. 6·31	27	188	1164	1613	140	902	1834

TABLE II.

Year.	No. of Days on which Photographs were taken.	Mean of Daily Areas. Umbræ.	Projected Whole Spots.	Faculæ.	Corrected for Foreshortening. Umbræ.	Whole Spots.	Faculæ.
1889	360	17·9	103	107	13·1	78·0	131
1890	361	21·3	133	273	15·5	99·4	304
1891	363	12·0	745	1322	86·2	569	1412
1892	362	25·5	1596	3230	186	1214	3270
1893	362	32·7	1983	2287	234	1464	2404
1894	364	31·7	1728	1666	231	1282	1877

TABLE III.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Spots North of the Equator. Mean of Daily Areas.	Spots North of the Equator. Mean Heliographic Latitude.	Spots South of the Equator. Mean of Daily Areas.	Spots South of the Equator. Mean Heliographic Latitude.	Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
	days			°		°	°	°
538	1893 Dec. 16·75	25	585	+13·85	1534	−10·74	− 3·95	11·60
539	1894 Jan. 13·09	27	490	+ 9·96	1063	−11·71	− 4·87	11·15
540	Feb. 9·43	28	236	+12·73	1094	−26·40	−19·47	23·98
541	Mar. 8·76	27	790	+14·55	142	− 9·85	+10·83	13·83
542	Apr. 5·06	27	685	+16·44	833	−19·50	− 3·29	18·12
543	May 2·31	28	419	+14·80	1451	−14·66	− 8·06	14·69
544	May 29·53	27	955	+11·59	1080	−14·27	− 2·14	13·01
545	June 25·73	27	885	+10·94	810	−13·51	− 0·74	12·17
546	July 22·94	27	1052	+10·29	425	−14·33	+ 3·21	11·45
547	Aug. 19·16	28	465	+10·73	271	−12·94	+ 2·02	11·54
548	Sept. 15·42	27	405	+12·06	862	−12·08	− 4·36	12·07
549	Oct. 12·70	27	344	+11·74	273	−12·04	+ 1·21	11·87
550	Nov. 9·00	28	290	+11·80	483	−16·17	− 5·69	14·53
551	Dec. 6·31	27	183	+12·00	719	−16·28	−10·54	15·41

TABLE IV.

Year.	No. of Days on which Photographs were taken.	Spots North of the Equator. Mean of Daily Areas.	Spots North of the Equator. Mean Heliographic Latitude.	Spots South of the Equator. Mean of Daily Areas.	Spots South of the Equator. Mean Heliographic Latitude.	Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
			°		°	°	°
1889	360	5·0	+ 7·26	73·0	−11·90	−10·68	11·61
1890	361	53·1	+22·20	46·3	−21·75	+ 1·73	21·99
1891	363	401	+20·49	169	−19·91	+ 8·52	20·31
1892	362	607	+15·09	607	−21·69	− 3·29	18·39
1893	360	517	+14·91	941	−14·26	− 3·93	14·49
1894	364	543	+12·31	739	−15·56	− 3·75	14·18

The principal features of the Sun-spot record for 1894, as brought out by the above tables, are :—

(1) A definite decrease in the mean daily areas of whole spots as compared with 1893 is shown, though this area was greater in 1894 than in 1892, and considerably greater than in 1883, the year of maximum in the preceding cycle.

(2) Faculæ have diminished in a yet higher ratio ; the decline in their case having set in strongly in 1893, a year earlier than with the spots, and having continued throughout 1894.

(3) Umbræ have shown hardly any decrease as compared with 1894.

(4) The decline as to whole spots has been limited to the southern hemisphere, the northern showing a slight recovery.

(5) But the southern hemisphere still remains the predominant one.

(6) Little change has taken place in the mean distribution of the spots in heliographic latitude, but the general trend of movement is still towards the equator.

(7) There is a slight reversal of this trend for the southern hemisphere considered separately, due chiefly to the great outburst of February 16 to March 1 in latitude $-32°$; but the movement towards the equator is very marked for the northern hemisphere.

(8) It may be added that no day in 1894 showed the Sun entirely free from spots.

Photographic Stellar Spectra of the Variable Star β Lyræ, and also of Types III. and IV. By F. McClean, M.A., LL.D., F.R.S.

The exceptional phenomena revealed in the spectrum of the variable star *β Lyræ* are well known, and hypotheses have been framed to account for them by Pickering and others.

The series of comparative photographs which accompany this paper (Plates 1 and 2) show distinctly the periodic variations of this spectrum. They extend from H_β to H. The negatives were taken during the autumn of 1895.

Pickering in 1891 identified the spectrum with hydrogen and the *Orion* stars. Lockyer in 1894 attributed the absorption spectrum to two stellar components, one resembling *Rigel* and the other *Bellatrix*. He found that the bright lines and the *Bellatrix* lines were displaced in the same direction, but not to the same extent.

On comparing the spectrum of *β Lyræ* with the spectra of other Helium stars, it appears that the nearest approach to it is the spectrum of *ζ Tauri*. The spectrum of this star has

therefore been mounted in conjunction with the series of *β Lyræ*. It will be seen that with small exceptions the whole of the principal absorption lines in the two spectra correspond. These lines also correspond, almost line for line, with the principal lines in the same portion of the spectrum of Clevèite Gas as determined by Runge and Paschen (*Astrophys. Journ.* Jan. 1896, see Note 2). The hydrogen lines and the K line are superadded. The absorption line, which appears most distinctly to shift its relative position, is the Helium line at w.l. 3964, close to H_ϵ. The curious effect of displacement and doubling seen in the Helium line at w.l. 4472 appears to be due to the alternate obscuration of this line and the adjacent iron (?) line at w.l. 4482, by the shift of the corresponding diffuse emission Helium line at w.l. 4472.

In mounting the photographs, the whole of the relative displacement has been given to the bright line spectrum, but of course this need not be the case. It appears, on the whole, as if the diffuse bright lines of the emission spectrum corresponded with the hydrogen lines and the principal Helium lines of the absorption spectrum.

On the seventh and the thirteenth days the two spectra appear nearly to correspond in position. At other times, from the thirteenth to the seventh day, the bright-line spectrum is displaced towards the red, and from the seventh to the thirteenth day towards the violet. There are however discrepancies in this general effect which it is difficult to reconcile.

The systematic classification of stellar spectra was established by Father Secchi in 1866 and 1867. The photographs which accompany this paper are included in his Types III. and IV. Stellar spectra of these types have been thoroughly investigated by Huggins, Dunér, Vogel, Lockyer, and others. Dunér's celebrated Memoir forms an exhaustive treatise on the subject.

The banded portions of these spectra, called "Dunér's Bands," are distinctly shown.

The photographs of Type III., in addition to the bands, show line absorption spectra in nearly all respects identical with Type II. (the solar type).

There is increased general absorption in the violet, and various groups of lines, due to calcium, manganese, and other substances, are intensified. The general character of the spectrum remains unchanged. The bands supervene gradually, and some of them can be recognised in spectra of Type II. The crucial band appears to be Band No. 5, which is only present in the characteristic spectra of this type. This band appears faintly on the transitional spectrum of *α Tauri* (*Aldebaran*), and the manner in which it there supervenes on the spectrum of Type II. appears to preclude the possibility of the adjacent bright band being other than an effect of contrast. The practical identity of the line absorption spectra of Types II. and III. indicates that the

transition from one to the other is due to the natural course of change in the condition of the stars themselves.

The stars of Type IV. are mostly below the 6th magnitude. Two different photographs are given of the star 152 Schjellerup of the $5\frac{1}{2}$ magnitude. This is Secchi's "Superba." Two hours' exposure was required, which accounts for the exaggerated distortion due to the changing amount of refraction during exposure. The value of the faint details is enhanced by the correspondence of the two photographs. The presence of a line absorption spectrum is distinctly shown, and it appears to agree to a marked extent with the usual line spectrum of Types II. and III. There appears to be no trace of Dunér's Band, No. 5 of Type III. The inference seems to be that spectra of Type IV. arise from a natural course of change in these stars, passing directly from Type II. They are stars of Type II. become less luminous, but not different in kind.

It is well known that the "Dunér Bands" of Type IV. are due to the absorption of hydrocarbon, being the reverse of the emission spectrum of hydrocarbon gas.

Notes.

Note 1.—Photographs of *β Lyræ*.

	d	h		d	h
No. 1 from min.	0	6	No. 7 from min.	7	0
2 „	1	1	8 „	8	0
3 „	2	19	9 „	8	5
4 „	4	1	10 „	8	21
5 „	5	0	11 „	11	2
6 „	6	0	12 „	12	2

Comparison spectra, *β Orionis* and *ζ Tauri*.

Note 2.—Principal lines in the spectrum of clevèite gas, from H_β to H_ζ Runge and Paschen, *Astrophys. Journ.* 1896 Jan. Lines of intensity 1 omitted.

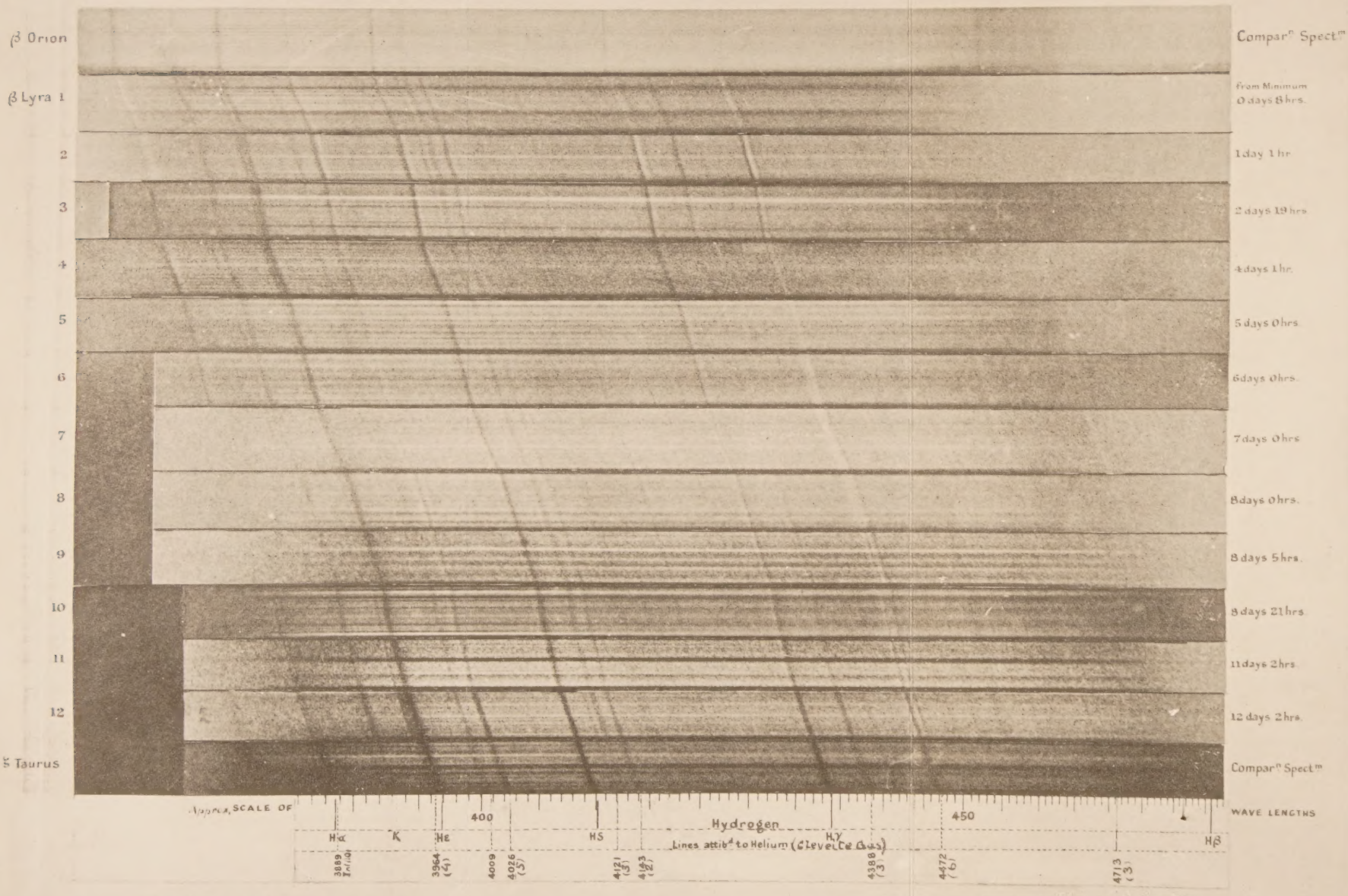
Wave length 3889.	Intensity 10	Wave length 4144.	Intensity 2
„ „ 3965.	„ 4	„ „ 4388.	„ 3
„ „ 4026.	„ 5	„ „ 4472.	„ 6
„ „ 4120.	„ 3	„ „ 4713.	„ 3

Note 3.—Secchi, *Comptes Rendus*, 1866 Octobre 8; *Memorie della Società Italiana*, 1867, 1868.

Note 4.—Stellar spectra of Type III.—*o Ceti* (showing bright lines, H_γ and H_δ), *α Tauri*, *α Orionis*, *α Scorpii*, *β Andromedæ*, *α Ceti*, *δ Ophiuchi*, *μ Geminorum*, *δ Virginis*, *β Pegasi*, *α Herculis*. Not included, *γ Eridani* and *μ Ursæ Majoris*.

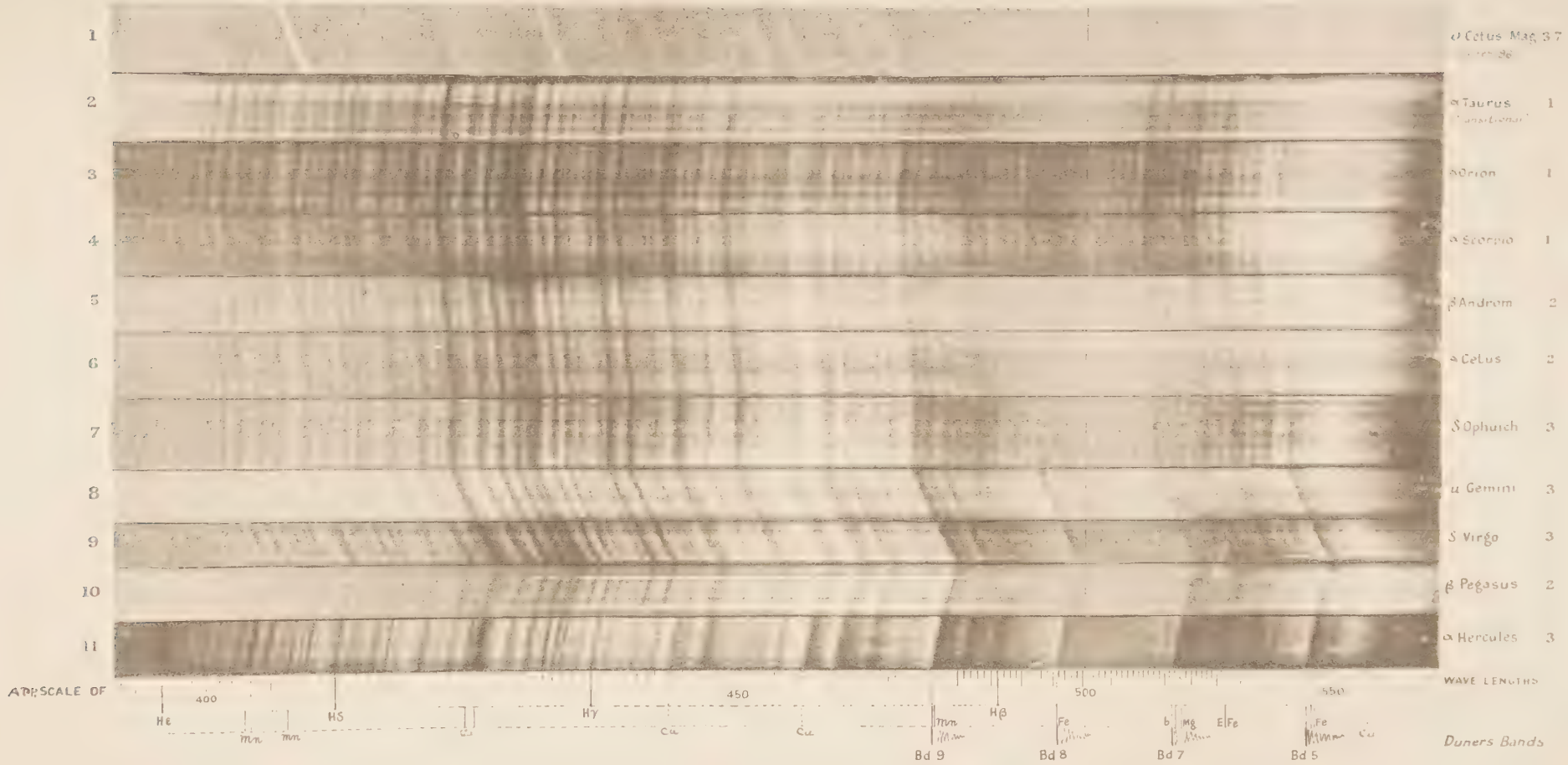
PHOTOGRAPHIC SPECTRA OF VARIABLE STAR β LYRA.

Magnitude 3 to 4. Period 12 days 22 hours. Secondary Minimum 6 days 11 hours.

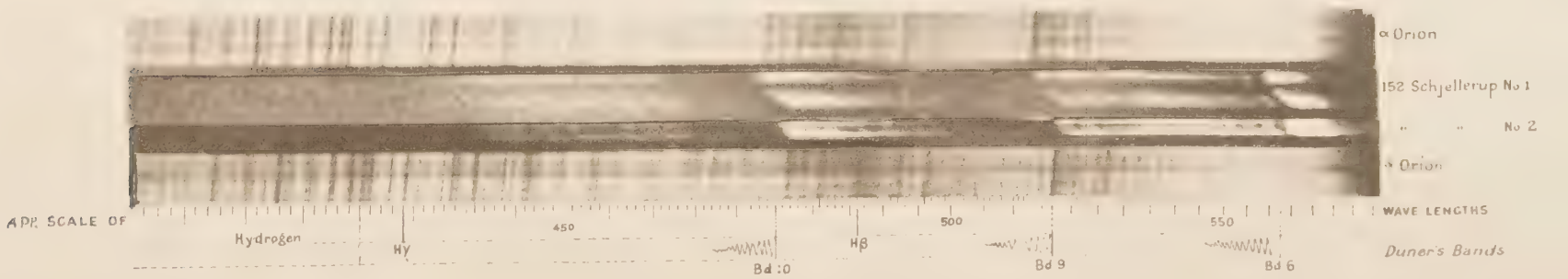


Note. *The inclination of the lines is caused by varying Refraction (due to varying Altitude) during Exposure.*

PHOTOGRAPHIC STELLAR SPECTRA OF TYPE III.



PHOTOGRAPHIC SPECTRUM OF SECCHI'S TYPE IV.



Note. The inclination of the lines is caused by varying Refraction

Note on the Effects of Distance upon the Spectra of Physical Clusters of Stars. By E. J. Stone, M.A., F.R.S., Radcliffe Observer.

I considered, in 1877, the nature of the spectra of physical clusters of stars of which the individual members were sufficiently near to each other, relatively to the distance of the stars generally, to sensibly influence—by their mutual gravitation and heating effects—the distribution of the coronal matter which surrounds an isolated star, such as our Sun. In the case of such a cluster, consisting of three, four, or any definite number of stars, the coronal matter would become distributed through a limited portion of space. I stated that in this case the brightness of the spectra of the individual stars would decrease in the proportion of the inverse square of the distance ; but that such would not be the case with the spectrum of the sensibly continuous luminous surface formed by the gaseous corona. And that consequently, although in the case of such clusters at moderate distances we might, and should, observe directly the spectra of the individual stars forming the cluster, yet at greater distances the light thus received might become less than that received from the sensibly continuous gaseous envelope.

My views were objected to on the grounds that the light of the corona around each star would decrease in the same way as that of the individual stars ; and such would have been the case, and the objection a fatal one to my views, if the coronal matter around each star of such a cluster remained isolated and not distributed over a finite space by the mutual actions of the individual stars of the system. But after I had called attention to the point that my reasoning applied to physical clusters with the necessary distributed gaseous matter over a limited space, no more was heard by me of this criticism.

But I have been surprised to read in Frost's English edition of Dr. Scheiner's *Treatise on Astronomical Spectroscopy*, p. 232, as follows :—

" This hypothesis has been criticised on various sides, and its principal fallacy may be easily seen. Stone overlooked the fact that the number of stars whose light enters the slit increases just in proportion as their brightness decreases."

Now what is here stated by the authors as a fact is certainly not true.

In the case of surfaces of sensibly continuous illumination the compensation mentioned is effective, but it would not be effective in the case of three, four, or any definite number of isolated stellar points.

It may perhaps save time to some who consult Frost's work if attention is called to an error in the numerical value assigned

to the constant number in Balmer's formula, which is given on p. 230.

The frequency

$$N = \frac{1}{\lambda}$$

is stated to be found for the hydrogen lines from the equation —

$$N = 2748 \cdot 13\,(1 - 4m^{-2})$$

and a reference is given to the *Phil. Mag.* 1890. But I find that—

$$N = 2742 \cdot 625\,(1 - 4m^{-2})$$

or

$$\lambda = 3646 \cdot 141 \frac{m^2}{m^2 - 4}$$

gives the standard wave lengths with much greater accuracy.

On the Comparison of Reflector and Portrait Lens Photographs.
By E. E. Barnard.

In the *Monthly Notices* for 1896 April Dr. Roberts has given a comparison of the photographic plates made with his 20-inch reflector, and with two portrait lenses of $3\frac{1}{2}$ and 5 inches diameter. These small lenses have foci of 9·56 inches and 19·22 inches respectively, while the 20-inch reflector has a focus of 98 inches. At the close of his paper Dr. Roberts takes occasion to criticise several of my star photographs, now in the possession of the Royal Astronomical Society, which were made at Mount Hamilton with the 6-inch Willard lens of 31 inches focus.

These comparisons of the portrait lenses with the reflector might be objected to upon several grounds. First of all, the only claims of superiority that I know of which have been urged in favour of the portrait lens are its advantages, on account of small scale and wide field of view, in showing very large and faint nebulous areas, the phenomena of the tails of comets, and the structural forms of the Milky Way. In these special fields it is supreme, and likely to remain so until some better instrument than any hitherto used has been devised for this class of work.

The method of comparison by counting the number of stars shown on equal areas of the reflector and portrait lens plates is not only not the best one, but is very unfair to the short focus lens. On account of the smaller scale of the portrait lens, what will appear as several stars on the reflector plate will often coalesce into one star on the plates with the portrait lens, and for this reason a count of the stars, particularly with a long exposure, must necessarily be favourable to the larger instrument.

A fairer way, and one freer from error, would be to select regions free from bright stars, on a plate of sufficiently short exposure to make identification of the stars an easy matter, and then see if the faintest stars were wanting on the small plates. An estimate of the difference of magnitude between the faintest stars that are shown on the small plates and the faintest on the reflector plates, will tell more concerning the relative penetrating powers of the two instruments than all the counts of individual stars that could ever be made, and this is equally fair to the reflector and the portrait lens.

To further show the fallacy of the method of counting the stars in a test of this kind, it is only necessary to call attention to the fact that a very slight difference in the actual magnitudes of the smallest stars shown on the two plates may double or treble the number of stars revealed by the larger instrument. In the Milky Way this difference would be still more increased.

In reference to my photographs which Dr. Roberts mentions, I would say that there must have been an interchange of dates on the two positives of the neighbourhood of γ *Cassiopeiæ*, which were sent to the R.A.S. The one he speaks of as having been made 1894 February 2, with three hours' exposure, can scarcely be the one he has examined, for on that plate γ *Cassiopeiæ* is 8° from the middle of the field, and at a point where all the small stars are defective from distortion. No one should attempt to count the stars under these conditions, and hence I assume this is really not the plate referred to (see note at end of this paper). There is another plate near the region of γ *Cassiopeiæ* which was made 1894 February 6, with $1^h\ 47^m$ exposure on a constantly thickening sky, which finally stopped the exposure. The effective exposure on this plate would be far less than this time, and I think an hour and a half would be a too liberal estimate of the equivalent time under ordinary conditions, and perhaps one hour would be nearer the mark. On this last plate γ *Cassiopeiæ* is about 4° from the centre; and in fairness no one ought to select such a position on a portrait lens plate for comparison with the central part of another picture. On this plate (assuming it is the one used by Dr. Roberts) he succeeded in counting 1,300 stars in an area of 2° square about γ *Cassiopeiæ* as a centre. In this same area he counted the following on his own plates with $2^h\ 12^m$ exposure :—

With $3\frac{1}{2}$-inch lens, 1,080 stars.
With 5-inch lens, 2,610 stars.
With 20-inch reflector, 17,100 stars.

After seeing his article, I was curious to know how many stars were really shown on my plate, in the exact region examined by him. Over a glass positive from this negative I placed a square aperture $2° \times 2°$ with γ *Cassiopeiæ* in the centre. On the positive was ruled a series of small squares to avoid confusion in the counting. This space was examined with a suitable magni-

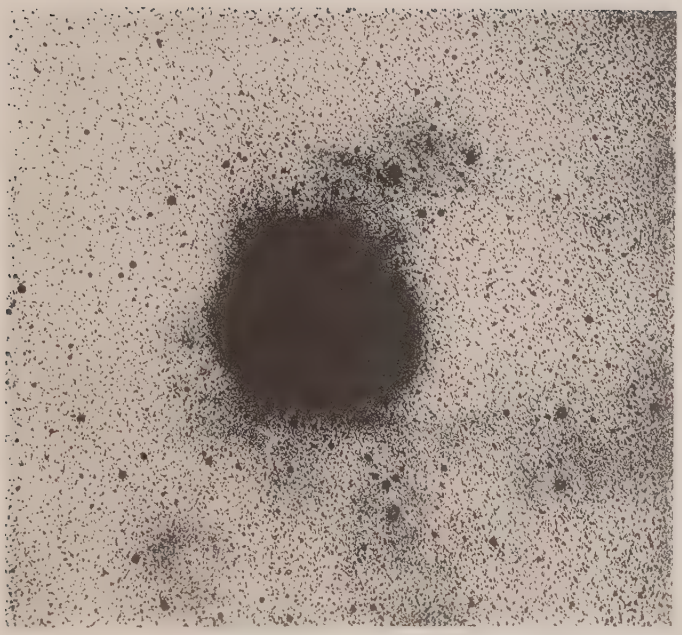
fying power, and the result was that 3,396 stars were counted where Dr. Roberts discovered only 1,300. This seems to me to speak very favourably for the performance of the Willard portrait lens under trying circumstances. The image of γ *Cassiopeiæ* on the original negative is round and sharp, and only 4′·5 in diameter. On his own plates Dr. Roberts found, with $2^h\ 12^m$ exposure, the image of γ *Cassiopeiæ* had the following diameters:—

With $3\frac{1}{2}$-inch lens, 18′·7.
With 5-inch lens, 10′·2.
With 20-inch reflector, 16′·9.

It would appear that these images are abnormally large compared with those of the Willard lens.

Dr. Roberts mentions the lack of details in the two fan-shaped nebulæ close to γ *Cassiopeiæ* which were discovered with the Willard lens. This was doubtless due to the short exposure and the thick sky. The night was not suited for the photography of nebulæ. In speaking of these two nebulæ Dr. Roberts says: "I may here state that the two fanlike nebulæ which have been referred to, were faintly shown on a photograph of the region of γ *Cassiopeiæ*, which was taken with the 20-inch reflector on 1890 January 17, but at that time I thought they were due to stains on the film." Considering the importance of these nebulæ, it is to be regretted that Dr. Roberts did not repeat his exposure to see if the markings were only stains on the plate. The discovery of these interesting objects might then have been credited to the 20-inch reflector. Referring to this same picture of 1890 January 17 in his book of celestial photographs, Dr. Roberts distinctly discredits the existence of any true nebulosity about γ *Cassiopeiæ*.

He has also taken occasion to notice two plates of the neighbourhood of the Pleiades made by me at Mount Hamilton. The first of these was given four hours' exposure 1893 December 1. Time has always been too precious to warrant the making of exposures on objects which were manifestly unsuited for my instrument, and those which had been successfully photographed elsewhere with instruments better adapted to the purpose. One of the objects thus recognised as beyond my reach was the Pleiades, and therefore I never made any photographs of that cluster to show the closer nebulosities which are mixed up with the brighter stars. Objects of this class belong entirely to large telescopes. The first of the photographs was made in the hope of showing certain vague nebulosities I had previously seen with the telescope north of the Pleiades. For this reason the cluster itself was placed some distance from the centre of the field, the suspected nebulous region being given preference of position. The positive of this plate sent to the R.A.S. was not sent in competition with photographs of the cluster made with more powerful telescopes, but simply to show the general appear-



EXTERIOR NEBULOSITIES OF THE PLEIADES.
E. E. Barnard.

LEEDS PHILOSOPH... LITERARY SOCIETY.

ance of the stars in that part of the sky, and as a supplement to the one with two nights' exposure, on which the star images were not good. On this four-hour plate the Pleiades are 3° from the centre of the field, and therefore not in the best position to show the faintest stars in that vicinity. On this positive Dr. Roberts counted in a space 2° by 2°, with η central, 825 stars, against the following with $2^h\ 50^m$ exposure made at his observatory:—

With the 5-inch lens, 953 stars.
With the 20-inch reflector, 3,470 stars.

By the same method used with γ *Cassiopeiæ* and with η central, I counted in the same area 1,042 stars distinctly shown. Why he should find so few stars on my plates when so many exist, I would not attempt to explain. The image of η *Tauri* on the original negative is 3'·9 in diameter, and is round and sharp. Traces of the exterior nebulosities are shown on this plate on each side of the cluster, and this led me to place the Pleiades more central in the long exposure made afterwards.

The other photograph of this region was taken 1893 December 6 and 8, and the whole exposure was $10^h\ 15^m$. The exposure was begun December 6, but the following night was cloudy, and the plate therefore lay in the camera from the 6th to the 8th. The camera box was of wood, which on Mount Hamilton is always subject to much change by shrinkage or expansion. Under these conditions it is really remarkable that after two entire days, one entire night, and parts of two other nights, it was possible to again so perfectly match the star images at the second exposure that it requires close examination to detect a slight overlapping of the star discs. With all these difficulties the picture admirably serves its purpose, since it was only intended to show the exterior nebulosities to which everything else was sacrificed. Dr. Roberts says of this picture, that the star images are elongated and overlapping; and he should have seen that it could not fairly represent a continuous exposure of $10\frac{1}{4}^h$. I fail, however, to see the force of his reasoning that because of these conditions, "some doubt would be cast on the reality of the distant nebulosity which is shown on the plate."

In reference to the slight elongation of the stars on this plate, mentioned by Dr. Roberts, where the plate was in the camera for over fifty hours, I think he can appreciate the difficulty of keeping the stars round even with short exposures, as will be seen by reference to his book of photographs, where quite a number of the pictures show defective star images. Plates 42 and 45 show strongly this elongation of the star images, and others in a lesser degree. Yet after all I fail to see how the slight elongation or overlapping of the stars in the Pleiades picture can have the least effect on the nebula itself, since the nebulosity is a surface and not a point of light. It would certainly get the full

benefit of the entire exposure, though the stars would not. On this plate the long exposure seems to have only slightly increased the diameters of the bright stars; the diameter of η measures $4'{\cdot}5$ against $3'{\cdot}93$ on the four-hour exposure. Both original negatives show considerable detail among the interior nebulosities, though the positives sent to the R.A.S. may not do so. The matter was not deemed of sufficient importance to make special positives for that purpose.

At a meeting of the B.A.A. on April 29, Dr. Roberts took a further opportunity to object to these star pictures, and is reported to have said the exterior nebulosities shown on my Pleiades photographs "were not nebulosity, and he made the assertion without fear of anyone proving the contrary." That these nebulosities exist as shown on my photographs there can be no doubt whatever. Indeed, it was the knowledge of their existence by visual observations alone that led me to make the photographs. The previous experience of Dr. Roberts with the diffused and faint nebulosity about 15 *Monocerotis* (*M. N.* vol. lvi. No. 2)—which was first shown to exist by the Willard lens—the discovery of which he at first discredited, might warrant some hesitation on his part in denying the existence of a similar region about the Pleiades.

In this connection I may mention that through the courtesy of Dr. Roberts I have a small glass positive of his photograph of the region of 15 *Monocerotis*. To my surprise, I find that his picture does actually show faintly this nebulosity, the existence of which he undertook to disprove by this very photograph. It is not shown so strongly as with the portrait lens, but all that is wanting to show it fairly well with his reflector is a somewhat longer exposure, and a larger plate to give more sky about it for contrast. The faint nebulosity will cover an entire plate of the size he now uses. I have compared his positive with an enlargement of my photograph of this region, not to count the stars, but to single out the faintest stars on his picture to see if they existed on mine. I was surprised to find how nearly my plate succeeded in showing every faint star on the other. There were some of his very faint stars not shown on my plate, but there would be scarcely half a magnitude between his faintest and my faintest. I am not sure but that fainter stars yet might have been shown on my plate were it not that the region possible for comparison on the two plates was covered with strong nebulosity on my plate in which very faint stars may have been lost.

Notwithstanding his condemnation of the faint nebulosities shown by portrait lenses to exist in certain parts of the sky, Dr. Roberts claims that his photographs of the dense globular clusters show essentially all these objects to be nebulous. As instances of this supposed nebulosity, he cites photographs of the following clusters, shown in his book of photographs of star clusters and nebulæ:—Messier 53, plate 29; M. 3, pl. 31; M. 5, pl. 33; M. 13, pl. 34; M. 12, pl. 35; M. 10, pl. 36;

M. 92, pl. 37 ; and M. 15, pl. 47. Speaking of these clusters, he says : "While the whole of the nebulosity has not been absorbed or utilised in the formation of the stars, some of the nebulosity, varying in extent and density, is shown on the photographs to be present in each cluster." He further endorses this statement in the notes in connection with the individual pictures.

If one examines the photographs referred to, the apparent nebulosity in most of them seems to be in all probability a photographic effect only, due to the crowding of the bright stars, combined with an unsteady atmosphere, and a lack of exact focus, and also further increased by the great enlargement from the originals. Take, for example, the cluster M. 3, which is perhaps the most nebulous-looking cluster in the entire book. If the small stars scattered everywhere on this plate are examined it will be seen that they are hazy and ill-defined like those of the same size in the cluster. These exactly resemble the photographic image of an out-of-focus star with too much subsequent enlargement. To prove the nebulosity of this cluster, Dr. Roberts compares this photograph with those of the very wide and loose clusters M. 11, pl. 40, and M. 37, pl. 18, and the double cluster of *Perseus*. In the latter the stars are widely separated, and there is consequently less chance of their running into each other through a lack of focus or by bad seeing. Such photographs cannot properly be used to prove the nebulosity of a closely packed globular cluster. If we look at the plate of M. 11, it will be seen that the small stars are ill-defined as if somewhat out of focus. A dense clustering of these stars would present a nebulous appearance, especially if the magnification was increased to correspond with that of the globular clusters. As a further example of this effect take plate 12, "Region of *Nova Aurigæ*." The stars scattered over this plate are hazy as though not exactly in focus. Compress these into a globular cluster, and increase the enlargement four times, and I think the result would be a splendid specimen of a "nebulous" globular cluster ; and yet I believe Dr. Roberts has used this very picture to prove that *Nova Aurigæ* was not nebulous.

If we should treat the small stars shown in the plate of the nebula of *Andromeda* in this same manner, another "nebulous" globular cluster would be the result. Another good example is plate 49, where the small stars all over the plate are ill-defined and hazy. There are also other plates of this kind that might be mentioned—viz. plates 14 and 38, where an imperfection of focus produces a defective and hazy appearance in the stars which might well lead to apparently highly interesting results if combined into a globular cluster. I have examined these globular clusters in the sky with the most powerful telescopic means, and have found it impossible to decide whether they were nebulous or not when the seeing was at all indifferent ; the bad seeing seemed to produce in them a haziness, much like nebulosity, by

the mixing of stray light. Under first-class conditions, however, when the air was very steady, the impression was that these clusters were free from true nebulosity.

A last word as to the relative value of the portrait lens and the reflector. The superiority of the one over the other will depend entirely on the object photographed. A short-focus portrait lens is only intended to show large structural details, such as the phenomena of comet tails, the great diffused nebulosities of the sky, the cloud-forms and details of the Milky Way, &c. When used for such work, no other form of instrument can equal it. When small details in limited areas are wanted, a larger instrument must be used, such for instance as Dr. Roberts's large reflector. For the small details in an object like the *Orion* nebula, it would be absurd to expect the best results from the small scale of a portrait lens. Yet the great curved nebula covering a large part of *Orion* is not only out of the reach of the large telescope, but it is best shown with an instrument beside which even the modest portrait lens is a giant. Still it is easy to imagine how poor these details shown in the great *Theta* nebula by a 20-inch reflector would appear, compared with those shown in another telescope with light and scale proportionally increased. If one compares the magnificent photograph of the cluster M. 13, in *Hercules*, made by Mr. W. E. Wilson, at Daramona, Ireland, with the photograph of the same object as shown in Dr. Roberts's book, with the same exposure, this difference will be more readily appreciated; and yet in this case the increase of aperture was only 4 inches.

In conclusion, let me say that specimens of my comet and Milky Way photographs, made with a portrait lens, are in the possession of the Royal Astronomical Society. An unprejudiced inspection of these will show their value to the science of astronomy. It must be understood, however, that they are to be looked at as pictures of the objects they represent, and are not to be examined with a microscope for details which in the nature of things it is impossible for them to show.

Kenwood Observatory, Chicago, Ills.:
1896 *June* 19.

P.S.—To see if any mistake had been made in dating the two positives of the region near γ *Cassiopeiæ* that are in the possession of the R.A.S., I sent tracings of them to Mr. Wesley, the Assistant Secretary of the R.A.S. He has kindly returned these tracings to me, since the above paper was written. He finds that they agree in date &c. with the positives, so that no mistake had been made. From this it appears that Dr. Roberts did actually use the 1894 February 2 photograph for comparison where the image of γ *Cassiopeiæ* is close to the edge of the plate and 8° from its centre, and where the small stars are either defective or entirely lost through distortion of the field !—E. E. B.

Observation of Comet f 1896 (*Perrine*), *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observation was made with the Sheepshanks' Equatorial, aperture 6·7 inches, by taking transits over two cross-wires at right angles to each other, and each inclined 45° to the parallel of declination. Magnifying power 55.

The initials C. D. are those of Mr. Davidson.

Greenwich Mean Solar Time.	Observer.	☄ − ✶R.A.	Corr. for Refraction.	Log. Factor of Parallax.	☄ − ✶N.P.D.	Corr. for Refraction.	Log. Factor of Parallax.	No. of Comps.	Apparent R.A. of ☄.	Apparent N.P.D. of ☄.	Comp. Star.
1896. d h m s		m s	s		′ ″	″			h m s	° ′ ″	
Nov. 4 8 54 8	C. D.	+0 2·12	0·00	9·5065	−6 3·9	−0·1	0 6971	6	20 18 47·09	66 11 26·7	*a*

Notes.

The observation is corrected for refraction, but not for parallax. It is also corrected for the error of inclination of the wires and for the motion of the comet.

The comet was extremely faint and difficult to observe.

Comparison Star.

Star's Name.	Assumed R.A. 1896·0.	Assumed N.P.D. 1896·0.	Authority.
	h m s	° ′ ″	
a Piazzi XX. 118	20 18 42·68	66 17 49·8	Berlin Astr. Gesell. Catalogue.

Royal Observatory, Greenwich:
1896 *November* 13.

Observations of Comet Perrine, 1896, November 2, at the Radcliffe Observatory, Oxford.

(Communicated by E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.)

The following comet observations were made with the 10-inch Barclay Equatorial, using the ring micrometer, with power 100.

Date.	G.M.T.	Local Sidereal Time.	Observer.	Comet *minus* Star (corrected for Refraction only). R.A.	N.P.D.	No. of Comps.	Apparent R.A. of Comet.	Parallax in R.A. p.	Log. $(p \times \Delta)$.	Apparent N.P.D. of Comet.	Parallax in N.P.D. q.	Log. $(q \times \Delta)$.	Ref.
1896.	h m s	h m s		m s	′ ″		h m s	s		° ′ ″	″		
Nov. 4	7 5 17	21 58 19	R.	+3 44·17	+2 24·1	7	20 18 54·07	+0·1	9·225	66 7 43·9	2·8	0·634	(*a*)
5	7 38 56	22 36 0	W.	+6 7·13	+9 28·1	6	20 17 10 06	+0·1	9·354	66 57 42·1	3·0	0·662	(*b*)

Observers' Remarks.

(*a*) The coma can be traced over 1′·40″; the observed condensation, in the *north preceding* part of the coma, is distinct, though not stellar.

(*b*) The comet is very faint, but the nucleus appeared stellar at times of better definition; magnitude 12. Noise and the faintness of the object rendered the observations difficult.

Observers: W., Mr. Wickham; R., Mr. Robinson.

Assumed Places of Comparison Stars.

Ref.	Mean R.A.	Reduction to Apparent R.A.	Mean N.P.D.	Reduction to Apparent N.P.D.	Authority.
	h m s	s	° ′ ″	′	
(*a*)	20 15 7·64	+2·26	66 5 38·7	−18·8	Berlin, B., A. G., 7638
(*b*)	20 11 0·69	+2·24	66 48 32·2	−18·2	Berlin, B., A. G., 7591

In the computation of the parallaxes the adopted value of the Sun's mean horizontal parallax is 8″·85; and the geocentric distances, Δ, are taken from the *Circular der Central-Stelle*, November 7.

Radcliffe Observatory, Oxford: 1896 *November* 13.

Observation of Comet Perrine, 1895, IV., at the Radcliffe Observatory, Oxford.

(*Communicated by E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.*)

The following comet observation was made with the 10-inch Barclay Equatorial, using the ring micrometer, with power 100.

Date.	G.M.T.	Local Sidereal Time.	Observer.	Comet *minus* Star (corrected for Refraction only). R.A.	N.P.D.	No. of Comps.	Apparent R.A. of Comet.	Parallax in R.A. p.	Log. $(p \times \Delta)$.	Apparent N.P.D. of Comet.	Parallax in N.P.D. q.	Log $(q \times \Delta)$.	Ref.
1896.	h m s	h m s		m s	′ ″		h m s	s		° ′ ″	″		
Feb. 23	17 29 34	15 38 57	R.	−0 39·80	+0 59·4	10	19 46 33·91	−0·14	9·5079	89 38 11·4	3·1	0·8381	(*a*)

Observer's Remarks.

Comet much fainter than Perrine-Lamp (which was observed earlier), but easily seen. Coma 1′ in diameter. Nucleus 11 or 12 magnitude. The comparison star double, components sensibly equal, mag. 8; the second star observed.

Observer: Mr. Robinson.

Assumed Place of the Comparison Star.

Ref.	Mean R.A.	Reduction to Apparent R.A.	Mean N.P.D.	Reduction to Apparent N.P.D.	Authority.
	h m s	s	° ′ ″	″	
(*a*)	19 47 13·75	−0·04	89 36 59·7	+12·2	Mean Lalande, 37815; Schjellerup, 7651; Lamont, 22104

In the computation of the parallaxes the adopted value of the Sun's mean horizontal parallax is 8″·85; and the geocentric distance, Δ, is taken from the *Astronomische Nachrichten*, No. 3327.

Radcliffe Observatory, Oxford: 1896 *November* 13.

Observations of Comets and Planets made with the 15-inch Dunecht Refractor and Wire Micrometer at the Royal Observatory, Blackford Hill, Edinburgh. By Dr. J. Halm.

(*Communicated by the Astronomer Royal for Scotland.*)

1896	M.T. Edinburgh.	Δα.	Δδ.	No. of Comp.	α App.	Log pΔ.	δ App.	Log pΔ.	Réduction to App. Pl.		No. of Comp. Star.
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
				Comet 1896 I.							
Mar. 12	9 21 5	+1 15·01	−2 1·8	18, 6	3 1 16 10	9·699	+48 36 27·2	0·659	−0·10	+17·2	1
15	12 14 32	+0 21·58	−7 39·1	6, 2	3 20 59·40	9·586	47 15 0·4	0·856	+0 06	+17.1	2
16	8 12 6	−1 35·75	−0 47·3	21, 7	3 25 21·86	9·649	46 54 59·0	0·549	+0·12	+17·1	3
16	8 57 14	−3 54·34	−0 59·1	12, 4	3 25 31·23	9·675	46 54 12·6	0·626	+0·12	+17·1	4
17	10 52 55	+3 51·44	−0 59·0	18, 6	3 30 44·86	9·664	46 29 10·2	0·782	+0·11	+16 8	5
18	10 24 49	+6 18·41	−7 2·2	15, 5	3 35 6·97	9·673	46 7 26·2	0 751	+0·11	+16·7	6
22	8 16 1	−1 51·57	−1 22·9	21, 7	3 49 44·26	9·634	44 50 30·8	0·583	+0·28	+16·5	7
				Comet 1896 III.							
Apr. 26	10 4 25	+2 8·62	+3 52·7	15, 5	3 18 38·97	9·496	+43 39 49·8	0 891	−0·22	+ 9·8	8
27	9 31 25	+1 31·95	+3 34·9	18, 6	3 14 51·87	9·558	45 51 2·5	0·869	−0·29	+ 9·7	9
29	11 1 12	−0 51·88	+6 40·7	21, 7	3 5 48·86	9·301	50 6 14·5	0·913	−0·45	+ 9·5	10
May 9	10 18 54	−6 4·57	+0 48·4	12, 4	2 6 7·40	9·049	63 52 17·8	0·882	−1·42	+ 4·6	11
10	10 20 11	+2 21·32	+7 59·5	18, 6	1 59 10·45	8 875	64 44 16·9	0·880	−1·52	+ 3·2	12
19	11 29 46	−0 32·22	−2 14·9	3, 1	0 54 6·47	9·764*n*	69 55 20·4	0·794	−1·86	− 3·1	13
25	12 11 2	−5 44·69	−1 46·4	15, 5	0 11 6·21	9·985*n*	71 38 25·6	0·620	−1·57	− 6·4	14
29	12 55 14	−6 26·82	−4 36·0	6, 2	23 43 0·29	0·037*n*	72 19 12·8	0·404	−1·19	− 8·0	15
30	12 44 25	+6 33·45	+6 16 6	12, 4	23 36 13·19	0·040*n*	72 26 26 8	0·412	−0·93	− 9·4	16
31	11 53 42	+2 8·84	−9 39·9	18, 6	23 29 38·85	0·030*n*	72 32 33·3	0·523	−0·89	− 9·5	17

Planet (71) *Niobe.*

1896.	M.T Edinburgh. h m s	Δα. (○ − ✶) m s	Δδ. (○ − ✶) ′ ″	No. of Comp.	α App. h m s	Log $p\Delta$.	δ App. ° ′ ″	Log $p\Delta$.	Reduction to App. Pl. s	″	No. of Comp. Star.
Jan. 15	10 8 19	+1 45·65	...	24	8 54 30·98	9·428*n*	...	...	+2·29	...	18
20	12 0 29	+2 54·23	−0 47·0	15, 5	8 48 27·66	8·887*n*	+25 36 42·3	0·651	+2·39	− 2·5	19
22	9 31 45	+0 0·21	−1 44·5	12, 4	8 46 6·98	9·428*n*	25 31 11·2	0·709	+2·42	− 2·6	20
22	9 48 49	+0 33·04	−6 15·5	8, 8	8 46 6·50	9·395*n*	25 31 13·8	0·699	+2·42	− 2·5	19
Feb. 1	9 57 40	+0 33·70	+6 51·5	18, 6	8 33 29·98	9·224*n*	24 55 44·8	0·678	+2·52	− 1·4	21
2	10 40 17	−0 43·80	+2 34·1	12, 4	8 32 12·49	8·985*n*	24 51 27·4	0·664	+2·53	− 1·4	21
3	8 35 58	+0 21·88	−2 18·5	18, 6	8 31 4·55	9·413*n*	24 47 30·2	0·712	+2·53	− 1·2	22
12	8 29 41	−0 32·88	−0 6·5	18, 6	8 20 24·82	9·321*n*	24 3 59·5	0·699	+2·54	− 0·3	23
					Planet (324)						
Jan. 20	10 16 26	−0 7·12	−0 52·2	6, 6	9 0 1·14	9·377*n*	+23 51 29·6	0·712	+2·33	− 3·5	24
20	10 39 17	−1 3·38	+6 57·7	18, 6	9 0 0·46	9·321*n*	23 51 32·2	0·701	+2·32	− 3·5	25
22	8 55 44	−2 18·21	+2 0·0	15, 5	8 57 50·08	9·491*n*	23 54 21·8	0·750	+2·36	− 3·5	24
Feb. 1	8 22 1	+0 19·74	−2 44·9	24, 8	8 46 30·16	9·470*n*	24 4 15·8	0·740	+2·51	− 2·5	26
2	10 1 34	−0 51·95	−2 12·2	15, 5	8 45 18·48	9·235*n*	24 4 48·5	0·689	+2·52	− 2·5	26
3	7 46 9	−1 52·07	−1 52·3	18, 6	8 44 18·37	9·501*n*	24 5 8·5	0·755	+2·53	− 2·4	26
10	7 18 6	+0 59·62	−5 1·7	15, 5	8 36 53·17	9·493*n*	24 5 3·8	0·751	+2·56	− 1·5	27
12	8 0 9	−1 1·69	−5 58·5	18, 6	8 34 51·87	9·418*n*	24 4 7·1	0·722	+2·57	− 1·4	27
17	8 32 50	−2 28·60	−3 18·6	15, 5	8 30 12·47	9·283*n*	23 59 57·8	0·695	+2·56	− 1·0	28
18	7 56 44	−3 19·10	−4 24·3	12, 4	8 29 21·97	9·366*n*	23 58 52·2	0·714	+2·56	− 0·9	28
21	8 27 26	+2 15·32	+4 47·0	18, 6	8 26 54·35	9·239*n*	23 54 48·3	0·690	+2·53	− 0·2	29

Planet (371)

1896.	M.T. Edinburgh.	Δα. (♂ − ✱)	Δδ.	No of Comp.	α App	Log $p\Delta$.	δ App.	Log $p\Delta$	Reduction to App Pl.	No of Comp. Star.
	h m s	m s	′ ″		h m s		° ′ ″		s ″	
Jan. 22	11 8 46	+1 7·51	−6 30·6	6, 2	9 0 27·08	9·172*n*	+11 52 44·7	0·794	+2·14 − 28	30
Feb. 1	8 55 8	+0 51·37	+6 3·7	24, 8	8 51 8·50	9·397*n*	+12 7 28·5	0 808	+2·27 − 3·0	31
12	10 44 40	−0 25·62	−1 31·7	18, 6	8 40 51·66	8·587*n*	+12 28 1·6	0·783	+2·34 − 3·0	32
Planet (121) *Hermione.*										
Feb. 18	8 39 11	+0 5·91	+5 23·9	8, 8	10 41 52·50	9·491*n*	+18 55 50·7	0·789	+2·49 −11·0	33
Planet (6) *Hebe.*										
June 21	11 36 59	−0 42·39	+1 29·3	18, 6	16 27 46·70	9·009	− 0 40 53·4	0·866	+3·23 −11·7	34
25	12 11 41	+0 55·78	−7 22·9	15, 5	16 24 36 01	9·236	− 0 58 2·7	0·867	+3·27 −11·5	35
26	11 56 48	−4 27·30	+0 35·7	3, 1	16 23 52·08	9·203	− 1 2 43·1	0·868	+3·29 −11·2	36
Planet (287) *Nephthys.*										
July 2	11 26 59	+1 24·20	+0 45·8	18, 6	20 19 48·88	9·249*n*	−11 19 29·6	0·895	+3·62 + 5·3	37
12	11 34 56	−1 29·66	−1 20·8	18, 6	20 11 44·35	9·016*n*	−12 22 1·9	0·911	+3·84 + 5·9	38
13	11 27 46	+2 22·83	+3 26·4	18, 6	20 10 51·22	9·030*n*	−12 28 58·3	0 911	+3·86 + 5·6	39
22	10 50 2	+0 24·54	+4 51·9	18, 6	20 2 34·27	8·998*n*	−13 36 48·2	0·915	+4·01 + 5·8	40
27	12 6 54	+2 32·39	−3 57·0	12, 4	19 57 53·13	8 700	−14 17 25·2	0·918	+4·07 + 5·3	41

Planet (386) 1894 *AY*.

1896.	M.T. Edinburgh.	Δα. (♂ − ☉)	Δδ. (♂ − ☉)	No. of Comp.	α App.	Log $p\Delta$.	δ App.	Log $p\Delta$.	Reduction to App. Pl.		No. of Comp. Star.
	h m s	m s	′ ″		h m s		° ′ ″		s	″	
July 13	12 46 6	+1 1·78	−5 43·5	18, 6	21 2 47·39	8·830*n*	+ 3 34 35·8	0·843	+3·43	+ 8·0	42
27	11 14 13	+2 57·65	−4 30·7	12, 4	20 53 42·81	9·027*n*	+ 2 12 35·9	0·852	+3·68	+ 9·8	43
Aug. 24	10 44 25	+1 14·91	+2 43·6	9, 3	20 34 0·52	8·562	− 2 31 0·4	0·876	+3·90	+11·5	44
25	9 54 32	−0 24·23	+3 59·8	18, 6	20 33 28·53	8·566*n*	− 2 42 32·6	0·877	+3·91	+11·6	45

Planet (304) *Olga*.

Aug. 24	11 24 13	−0 33·45	+5 19·0	18, 6	22 0 49·34	8·496*n*	− 7 8 33·4	0·895	+4·08	+18·4	46
25	9 19 8	−1 1·89	+1 2·0	15, 5	22 0 19·24	9·290*n*	− 7 26 9·8	0·889	+4·09	+18·4	47

Planet (61) *Danaë*.

Aug. 24	12 55 19	−2 47·59	−6 8·6	9, 3	22 0 19·78	9·022	−15 14 57·9	0·918	+4·26	+18·4	48
25	10 49 55	−3 45·74	−2 59·0	12, 4	21 59 21·63	8·876*n*	−15 11 48·3	0·920	+4·26	+18·4	48

Mean Places of Comparison Stars.

No.	R.A. 1896·0. h m s	Decl. 1896·0. ° ′ ″	Authority.
1	3 0 1·19	+48 38 11·8	A.G.Z. Bonn.
2	3 20 37·76	+27 22 22·4	,,
3	3 26 57·49	+46 55 29·2	,,
4	3 29 25·45	+46 54 54·6	,,
5	3 26 53·31	+46 29 52·4	,,
6	3 28 48·45	+46 14 11·7	,,
7	3 51 35·55	+44 51 37·2	,,
8	3 16 30·57	+43 35 47·3	,,
9	3 13 20·21	+45 47 17·9	,,
10	3 6 41·19	+49 59 24·3	,,
11	2 12 13·39	+63 51 24·8	A.G.Z. Hels. Gotha.
12	1 56 50·65	+64 36 14·2	,, ,,
13	0 54 40·55	+69 57 38·4	A.G.Z. Christiania.
14	0 16 52·47	+71 40 18·4	Bonn, Beob.
15	23 49 28·30	+72 23 56·8	Arg. Oeltzen.
16	23 29 40·67	+72 20 19·6	,,
17	23 27 30·90	+72 42 22·7	Bonn, Beob.
18	8 52 43·04	+25 48 58·0	Lalande.
19	8 45 31·04	+25 37 31·8	Bessel-Weisse.
20	8 46 4·35	+25 32 58·3	,,
21	8 32 53 76	+24 48 54·7	A.G.Z. Berlin B.
22	8 30 40·14	+24 49 49·9	,, ,,
23	8 20 55·16	+24 4 6·3	,, ,,
24	9 0 5·93	+23 52 25·3	,, ,,
25	9 1 1·52	+23 44 38·0	,, ,,
26	8 46 7·91	+24 7 3·2	,, ,,
27	8 35 50·99	+24 10 7·0	,, ,,
28	8 32 38·51	+24 3 17·4	,, ,,
29	8 24 36·50	+23 50 1·5	,, ,,
30	8 59 17·43	+11 59 18·1	Lalande.
31	8 50 14·86	+12 1 27·8	Bessel-Weisse.
32	8 41 14·94	+12 29 36·3	Lalande.
33	10 41 44·10	+18 50 37·8	A.G.Z. Berlin A.
34	16 28 25·86	− 0 42 11·0	Bessel-Weisse.
35	16 23 36·96	− 0 50 28·3	Bonn, Beob.
36	16 28 16·09	− 1 3 7·6	½ (Schj. + Gött.).
37	20 18 21·06	−11 20 20·7	Bessel-Weisse.

No.	R.A. 1895·0. h m s	Decl 1896·0. ° ′ ″	Authority.
38	20 13 10·17	−12 20 47·0	Bessel-Weisse.
39	20 8 24·53	−12 32 30·3	Lamont.
40	20 2 5·72	−13 41 45·9	Bessel-Weisse.
41	19 55 16·67	−14 13 33·5	,,
42	21 1 42·18	+ 3 40 11·3	A.G.Z. Albany.
43	20 50 41·48	+ 2 16 56·8	,,
44	20 32 41·71	− 2 33 55·5	Lamont.
45	20 33 48·85	− 2 46 44·0	Bessel-Weisse.
46	22 1 18·71	− 7 14 10·8	,,
47	22 1 17·04	− 7 27 30·2	,,
48	22 3 3·11	−15 9 7·7	Argel. Zonen.

Notes.

March 16.—Comet faint; clouds.
March 22.—Comet very faint; moonlight.
April 29.—Comet circular, with nucleus of about 10th magnitude.
May 9.—Observation interrupted by clouds. May 19.—As on May 9.
May 25.—Comet exceedingly faint, scarcely visible. The same for all the following observations of this comet.
May 31.—Possibly the M.T. of this observation is 10 min. too late.

Observations of Phenomena of Jupiter's Satellites at Windsor, New South Wales, in the Year 1896. By John Tebbutt.

Day of Obs. 1896.	Satellite.	Phenomenon.	Phase.	Aperture of Telescope.	Mag. Power.	G.M.T. of Observation. h m s	Mean Time of *N. Almanac.* h m s
Jan. 22	II.	Occ. D.	First contact	$4\frac{1}{2}$ in.	120	23 44 31	
22	II.	Ecl. D.	Last seen	,,	,,	23 47 11	23 46 36
26	I.	Tr. Ingr.	Ext. contact	8 in.	138	23 58 5	
27	I.	,,	Bisection	,,	,,	0 0 30	
27	I.	,,	Int. contact	,,	,,	0 2 24	
27	I.	Ecl. R.	First seen	$4\frac{1}{2}$ in.	120	23 29 57	23 29 33
Feb. 3	I.	Occ. D.	First contact	,,	,,	22 47 52	
3	I.	,,	Bisection	,,	,,	22 50 21	22 50
3	I.	,,	Last seen	,,	,,	22 52 21	
4	I.	Ecl. R.	First seen	8 in.	90	1 23 50	1 24
4	I.	,,	Full brightness	,,	,,	1 26 35	
18	I.	Tr. Ingr.	Ext. contact	,,	300	23 39 2	
18	I.	,,	Bisection	,,	,,	23 40 41	23 39
18	I.	,,	Int. contact	,,	,,	23 42 31	
19	I.	Ecl. R.	First seen	,,	138	23 41 48	23 42 7
19	I.	,,	Full brightness	,,	,,	23 46 3	
26	I.	Occ. D.	First contact	,,	,,	22 31 25	
26	I.	,,	Bisection	,,	,,	22 33 15	22 32
26	I.	,,	Last seen	,,	,,	22 34 30	
26	III.	Ecl. R.	First seen	,,	,,	23 41 4	23 41 46
26	III.	,,	Full brightness	,,	,,	23 46 28	
27	I.	,,	First seen	,,	,,	1 36 52	1 37 3
27	I.	,,	Full brightness	,,	,,	1 40 9	
Mar. 3	II.	Tr. Egr.	Bisection	$4\frac{1}{2}$ in.	120	21 17 7	21 21
3	II.	,,	Ext. contact	,,	,,	21 20 32	
4	III.	Occ. D.	First contact	,,	...	20 22 28	
4	III.	,,	Bisection	,,	...	20 25 57	20 26
4	III.	,,	Last seen	,,	...	20 28 47	
5	III.	Occ. R.	First seen	8 in.	138	0 0 2	
5	III.	,,	Bisection	,,	,,	0 1 17	0 5
5	III.	,,	Last contact	,,	,,	0 2 47	
5	III.	Ecl. D.	Last seen	,,	,,	0 11 18	0 10 39

Day of Obs. 1896.		Satellite.	Phenomenon.	Phase.	Aperture of Telescope.	Mag. Power.	G.M.T. of Observation. h m s	Mean Time of *N. Almanac.* h m s
Mar.	5	I.	Occ. D.	First contact	8 in.	230	0 17 50	
	5	I.	,,	Bisection	,,	,,	0 19 44	0 19
	5	I.	,,	Last seen	,,	,,	0 21 20	
	5	I.	Tr. Ingr.	Ext. contact	,,	138	21 40 2	
	5	I.	,,	Bisection	,,	,,	21 42 2	21 38
	5	I.	,,	Int. contact	,,	,,	21 43 21	
	5	I.	Tr. Egr.	Int. contact	,,	,,	23 54 55	
	5	I.	,,	Bisection	,,	,,	23 56 59	23 58
	5	I.	,,	Ext. contact	,,	,,	23 59 24	
	6	I.	Ecl. R.	First seen	,,	74	22 0 31	22 0 50
	6	I.	,,	Full brightness	,,	,,	22 4 15	
	10	II.	Tr. Egr.	Bisection	,,	,,	23 41 4	23 44
	10	II.	,,	Ext. contact	,,	,,	23 43 48	
	11	IV.	Ecl. R.	First seen	,,	,,	0 23 58	0 27 44
	11	IV.	,,	Full brightness	,,	,,	0 31 55	
	15	III.	Shd. Egr.	Int. contact	,,	168	21 40 56	
	15	III.	,,	Half off	,,	,,	21 46 0	21 53
	15	III.	,,	Last seen	,,	,,	21 48 29	
	19	II.	Ecl. R.	First seen	,,	112	23 20 11	23 20 21
	19	II.	,,	Full brightness	,,	,,	23 23 53	
	20	I.	Tr. Ingr.	Ext. contact	,,	168	1 17 14	
	20	I.	,,	Bisection	,,	,,	1 18 59	1 17
	20	I.	,,	Int. contact	,,	,,	1 21 29	
	20	I.	Occ. D.	First contact	,,	,,	22 22 34	
	20	I.	,,	Bisection	,,	,,	22 24 36	22 26
	20	I.	,,	Last seen	,,	,,	22 27 0	
	22	III.	Tr. Egr.	Int. contact	,,	,,	21 5 19	
	22	III.	,,	Bisection	,,	,,	21 7 39	21 13
	22	III.	,,	Ext. contact	,,	,,	21 12 13	
Apr.	5	I.	Occ. D.	First contact	,,	,,	20 34 52	
	5	I.	,,	Bisection	,,	,,	20 37 26	20 38
	9	III.	Ecl. D.	Began to fade	,,	74	20 5 25	
	9	III.	,,	Last seen	,,	,,	20 10 58	20 9 8
	12	I.	Occ. D.	First contact	,,	168	22 28 12	
	12	I.	,,	Bisection	,,	,,	22 31 37	22 32
	12	I.	,,	Last seen	,,	,,	22 32 57	
	13	II.	Ecl. R.	First seen	,,	,,	20 22 40	20 23 3

Day of Obs. 1896.	Satellite.	Phenomenon.	Phase.	Aperture of Telescope.	Mag. Power.	G.M.T. of Observation. h m s	Mean Time of *N. Almanac.* h m s
Apr. 13	II.	Ecl.R.	Full brightness	8 in.	168	20 26 56	
13	I.	Shd. Ingr.	First contact	,,	,,	21 4 20	
13	I.	,,	Half on	,,	,,	21 6 50	21 6
13	I.	,,	Int. contact	,,	,,	21 8 29	
13	I.	Tr. Egr.	Int. contact	,,	,,	22 5 15	
13	I.	,,	Bisection	,,	,,	22 8 9	22 9
13	I.	,,	Ext. contact	,,	,,	22 10 49	
14	I.	Ecl. R.	First seen	,,	,,	20 35 6	20 35 13
14	I.	,,	Full brightness	,,	,,	20 37 54	
16	III.	Occ. R.	Last contact	,,	,,	22 28 51	22 33
18	II.	Tr. Ingr.	Int. contact	,,	,,	22 44 45	22 43
21	I.	Ecl. R.	First seen	,,	74	22 30 33	22 30 42
21	I.	,,	Full brightness	,,	,,	22 33 9	
28	I.	Occ. D.	First contact	,,	300	20 49 19	
28	I.	,,	Bisection	,,	,,	20 51 34	20 52
28	I.	,,	Last seen	,,	,,	20 52 49	
29	I.	Tr. Egr.	Bisection	,,	138	20 27 3	20 28
29	I.	,,	Ext. contact	,,	230	20 29 53	
May 6	I.	,,	Int. contact	,,	168	22 20 44	
6	I.	,,	Bisection	,,	,,	22 23 54	22 24
6	I.	,,	Ext. contact	,,	,,	22 25 48	
7	I.	Ecl. R.	First seen	,,	,,	20 50 25	20 50 32
7	I.	,,	Full brightness	,,	,,	20 53 53	
11	III.	Tr. Ingr.	Ext. contact	,,	132	21 11 6	
11	III.	,,	Bisection	,,	,,	21 14 21	21 14
11	III.	,,	Int. contact	,,	,,	21 18 15	
16	IV.	Ecl. D.	Began to fade	,,	168	19 59 54	
16	IV.	,,	Last seen	,,	,,	20 7 10	20 3 53
29	III.	Occ. D.	First contact	,,	,,	19 41 52	
29	III.	,,	Bisection	,,	,,	19 46 11	19 46
29	III.	,,	Last seen	,,	,,	19 48 26	
29	II.	,,	First contact	,,	,,	20 8 23	
29	II.	,,	Bisection	,,	,,	20 10 12	20 10
29	II.	,,	Last seen	,,	,,	20 12 17	
29	I.	Tr. Ingr.	Ext. contact	,,	,,	20 28 14	
29	I.	,,	Bisection	,,	,,	20 30 59	20 28
29	I.	,,	Int. contact	,,	,,	20 33 23	

In addition to the preceding observations the following times were noted, when the centres of certain objects were on the central meridian of the planet :—

Day of Obs. 1896	Object.	Aperture of Telescope.	Mag. Power.	G.M.T. h m s
Mar. 3	Shadow of Satellite II.	4½ in.	120	21 34 15
5	„ „ I.	8 in.	138	23 39 17
11	„ „ II.	„	168	0 4 15
29	Satellite III.	„	„	23 9 32
Apr. 13	Shadow of Satellite I.	„	„	22 9 18
29	„ „ I.	„	138	20 25 4
May 6	„ „ I.	„	168	21 20 14
24	Satellite IV.	„	„	20 4 1

Notes.

January 22.—Sky brilliantly clear, but Moon present ; the satellite began to fade in eclipse when in contact with the limb.

January 26 and 27.—Images steady and definition pretty good for the transit ingress. Sky clear, but bright Moon and images tremulous and badly defined at the eclipse. The satellite was suspected 9·5 seconds earlier, and came out very close to the limb.

February 3.—Images steady and pretty well defined.

February 4.—Sky beautifully clear and definition excellent. When first seen the satellites are usually copper-coloured specks, but on this occasion the satellite was first seen as a minute silvery speck close to the limb.

February 18.—Definition pretty good.

February 19.—Sky clear, but images slightly boiling.

February 26.—Images tremulous and not well defined at the occultation. Sky clear and images pretty well defined at the eclipse. The Moon was not far from the planet, and the time of first seeing is considered rather late.

February 27.—Sky beautifully clear, but Moon present.

March 3.—Planet boiling at internal contact; definition better at the other phases. The transit of the shadow of II. across the central meridian was estimated.

March 4.— Observation immediately after sunset.

March 5.—Sky clear and steadiness and definition pretty satisfactory at the occultation reappearance and eclipse disappearance. The satellite was very small at reappearance from occultation and immediately began to fade in eclipse. It was suspected 8 seconds after the recorded time of last seen. Steadiness and definition satisfactory at the occultation disappearance, and pretty satisfactory at the transit ingress. At the meridian transit of the shadow of I. and the transit egress of I. these conditions greatly improved. The transit of the shadow of I. was estimated.

March 6.—Sky clear and objects pretty steady and well defined.

March 10.—Good definition.

March 11.—The transit of the shadow of II. was observed by means of the micrometer threads. Sky very clear and definition good at the eclipse reappearance ; the satellite came out close to another.

March 15.—Good definition.

March 19.—Planet occasionally dimmed by light clouds, but it shone bright and clear at the critical time. The satellite came out close to the first.

March 20 —Images tremulous and badly defined at the transit ingress, more particularly at the internal contact. The definition for the first two phases of the occultation disappearance was pretty good, but not for the last.

March 22.—Images steady and well defined and observations pretty good.

March 29.—The transit of III. over the central meridian was observed by means of the micrometer threads. The satellite was seen as a dark spot. A dark spot on the planet itself was observed to cross the meridian eight minutes later, and of the two objects the satellite was the darker.

April 5.—Definition not good and images tremulous.

April 9.—Beautifully clear, but twilight pretty strong. The time of beginning to fade was unusually well observed by comparison with another satellite.

April 12.—Definition not good, and last phase very difficult of observation.

April 13.—Sky clear, but definition not good. Satellite II. was suspected five seconds earlier than the recorded time. The transit of the shadow of I. across the central meridian was determined by estimation only.

April 14.—Sky beautifully clear and definition pretty good.

April 16.—Sky beautifully clear and definition pretty good; observation pretty accurate.

April 18.—Definition remarkably good.

April 21.—Sky beautifully clear, but images tremulous and ill-defined. The satellite was suspected four seconds before the recorded time.

April 28.—Good definition, except at final disappearance, when the limb was disturbed.

April 29.—The transit of the shadow was observed by means of the micrometer threads.

May 6.—The transit of the shadow was observed by estimation only. The definition was very bad at the transit of I., and the observations are therefore very unsatisfactory.

May 7.—Sky clear and steadiness and definition pretty satisfactory. The satellite was suspected ten seconds earlier than the recorded time.

May 11.—Images very tremulous and ill-defined and the times very unsatisfactory.

May 16.—Satellite suspected to be fading $1^m\ 20^s$ earlier than the recorded time. Sky beautifully clear, but twilight had scarcely disappeared. Images steady and well defined and observation of final disappearance good.

May 24.—The satellite was watched at intervals from $19^h\ 22^m$ to $21^h\ 23^m$ and found to be perfectly black—as black, indeed, as I have ever seen a shadow of a satellite. Neither the ingress nor the egress could be observed, and the transit across the central meridian was determined by estimation. The satellite differed in its appearance from the shadows in that it seemed to be in space between the observer and the surface of the planet.

May 29.—Bad definition throughout.

An occulting bar was not employed in the eclipse observations. The times given are the Windsor mean times of observation diminished by $10^h\ 3^m\ 20^s$ and entered to the nearest second. The observations of full brightness in the eclipses are at the best only roughly approximate. In determining these times the increasing light of the satellite was repeatedly compared with the other visible satellites.

Private Observatory, Windsor, N.S. Wales:
1896 *September* 5.